Food and Agriculture Organization of the United Nations

European Bank for Reconstruction and Development

CAIRO WATER WEEK



FAO at Cairo Water Week 2026

25 – 29 October

Maximizing water productivity in agriculture: Evidence from remote sensing and economic analysis

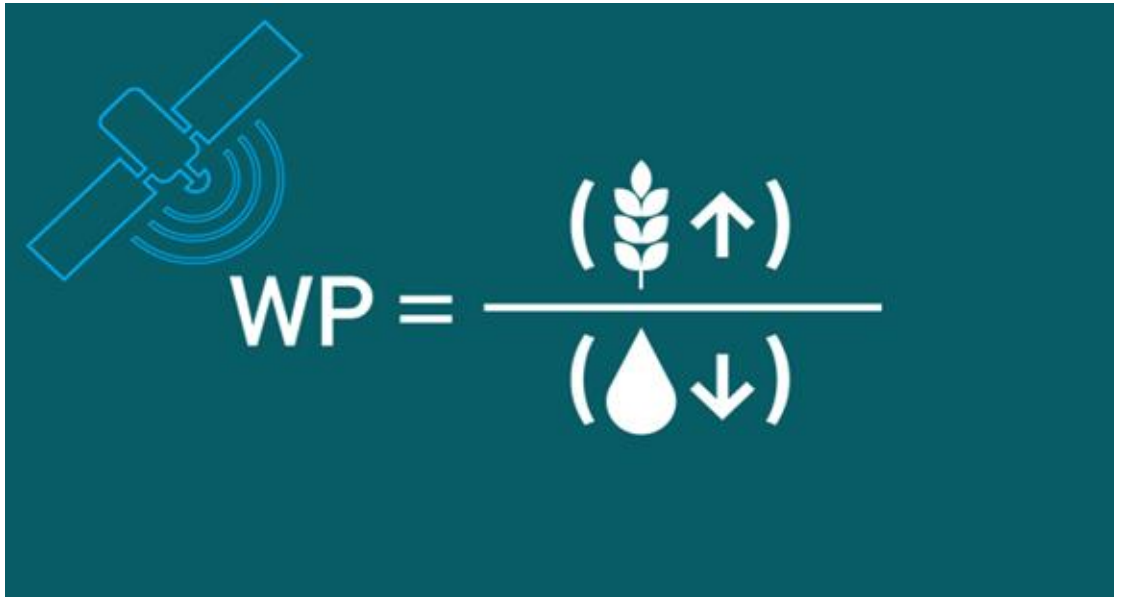
Paula Uyttendaele, Irrigation Engineer, CFIC
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Nina Coates, Economist, CFID

Remote sensing of water productivity

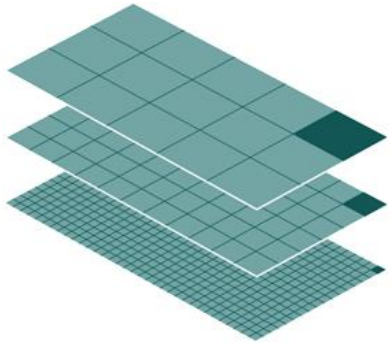
Water productivity in agriculture measures the output (kg) per unit of water consumed (m^3).

Satellites can help monitor water productivity in cost-effective ways.

Increasing water productivity is a globally recognized target (SDG 6.4)



Near-real time (every 10 days) data on biomass development and water consumption (actual evapotranspiration), in addition to agro-climatic parameters on a daily time step (reference ET and precipitation).
Spatial resolution ranges between 300 m and 20 m

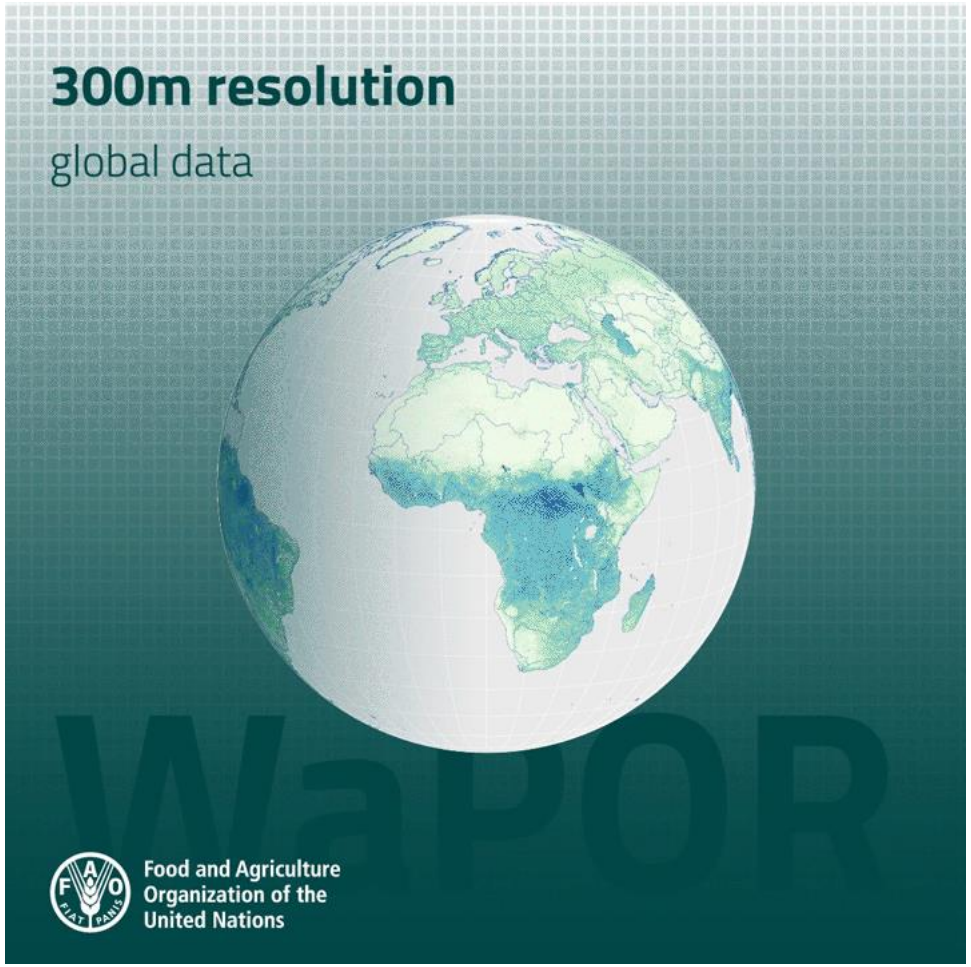


300m

100m

20m (new test 10 m, daily data)

https://data.apps.fao.org/wapor



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CAIRO WATER WEEK



Key Performance Indicators: Water, Productivity & Irrigation

1 Crop Water Requirement (ETc)

Water needed under standard conditions.

$$ET_c = K_c \times ET_o$$

2 Actual Water Consumption (AETI)

Water actually consumed by evapotranspiration and interception.

AETI

3 Adequacy

How well actual water supply meets crop water requirement.

$$\text{Adequacy} = \frac{\text{AETI}}{ET_c}$$

4 Uniformity

Spatial consistency of water use or crop performance across fields.

Lower variability = better uniformity

5 Yield

Harvested production per unit area.

kg/ha or t/ha

6 Water Productivity (WP)

Production generated per unit of water consumed.

$$\text{WP} = \frac{\text{Yield}}{\text{AETI}}$$

7 Economic Water Productivity (EWP)

Margin per unit of water consumed.

$$EWP = \frac{Price \times Yield - Costs}{\text{AETI}}$$

Together, these indicators help translate remote sensing into actionable investment insights.

What WaPOR adds to the investment cycle

1	2	3	4	5	6
Diagnostics	**Design**	**Prioritization**	**Implementation Finance**	**M&E**	**Policy & Scaling**
Baseline (ET, biomass, water productivity) and land use; identify hotspots of inefficient water use and low productivity	Quantify yield gaps & seasonal stress in crops. Potential water savings, scenario analysis (rainfed – irrigated, drip vs flood); economic analysis	Compare agriculture productivity with consistent metrics; rank by ET,WP biomass gap or area.	Near-real-time monitoring of crop water use; early warning; adaptive management	Independent, time-series measurement as indicators, baseline scenario vs post investment	Comparable cross-country evidence for allocation, pricing and incentive reforms

Food Security in the SEMED region
3.3: Maximizing Water Productivity

Objective

Generate the evidence base, policy guidance and investment options that water scarce SEMED countries need to raise economic water productivity in irrigated agriculture, combining remote sensing, hydrological analysis and ground-truth field data.

Key Deliverables

1

Water productivity mapping

Mapping of stakeholders and economic water productivity in selected irrigated areas, integrating remote-sensing with field data

2

Policy guidance

To improve scenarios of water demand, value addition and WP through investments in agriculture, water optimization and processing technologies

3

Investment roadmap

Investment options to improve selected value chains
Examples: data and forecasting, rehabilitation/modernization irrigation, post-harvest and logistics.

4

National consultation

Workshops to present, discuss and validate findings with public and private stakeholders incl. the policy guidance note, investment roadmap & supporting communication products.

THE CASE STUDIES

Four countries, four crop systems, one question: how much value does each cubic metre create?

Morocco

Avocado

R'mel, Loukkos irrigated perimeter

62 farms

346 ha of young and mature orchards, 2025 season

INVESTMENT LENS

High-value perennial under climate and land area constraints.. Focus on explaining yield gaps and what water is really applied.

Jordan

Citrus

Northern Jordan Valley

113 farms

700 crop plots, 11 citrus species; WaPOR 2022–2025

INVESTMENT LENS

Forward looking export-oriented irrigation. Focus on scheduling, reliability and improved competitiveness

Tunisia

Cereals

Jendouba

2 crop seasons

Dry year 2022/23 compared with wet year 2023/24

INVESTMENT LENS

Staple crops in drylands. Focus on drought risk and supplementary irrigation potential.

Palestine

Date palm

Jericho, West Bank

100 farms

Valid yield records from 112 surveyed; WaPOR Oct 2022–Sep 2023

INVESTMENT LENS

High-value perennial orchards. Focus on modernization, fine-tuning irrigation and improving crop management.

COMMON METHOD

One method in all four countries: satellite data, field data and economics combined

1 Satellite data: WaPOR v3, Level 3

Actual evapotranspiration and interception (AETI) and biomass at 20 m, every 10 days; reference ET and rainfall daily.

2 Field survey: the ground truth

Farm boundaries, crop and tree age, yield, applied water and practices. Collected differently in each country.

3 Economic analysis

Prices and costs turned into value per cubic metre: gross revenue and margin.

INDICATORS

AETI
water actually consumed

Adequacy
AETI ÷ crop water need

Yield
kg/ha

Physical water productivity
yield ÷ water, kg/m³

Economic water productivity
value ÷ water, per m³

DIAGNOSIS AND DECISION

- Where is water short, wasted or well used?
- Which age class, crop, practice or market explains the gap between farms?
- What should be decided: scheduling? Allocation?
- Though outside of the scope of the study, market factors such as quality and grading should be further investigated

GROUND-TRUTHING

Ground-truthing was tailored to each case, from metered farms to national statistics

Case	Field sample	What the survey collected	Water applied	Prices and costs
Morocco avocado	62 farms (346 ha), 2025 season	Yield, tree age, rootstock, water source, irrigation calendar	Reported; estimated from flow, duration and frequency, not metered	Prices and costs; net value for 38 farms (energy and fertiliser costs missing)
Jordan citrus	113 farms, 700 crop plots; stratified random sample (University of Jordan, Nov 2025–Jan 2026)	Yield per tree, orchard age, density, fertiliser, pesticides	Flow measured on site by the survey team (timed-can method)	Post-harvest phone follow-up for prices; MoA price statistics
Tunisia cereals	No farm survey; WaPOR 2022–2024 and official statistics	Area, yield and revenue by governorate; farm systems (Jendouba, 2023)	No comprehensive water-use data; irrigation not split by crop	Regional-average cost estimates; crop budgets needed
Palestine date palm	112 farms (100 valid, trees 8 years or older); tree age from Landsat time series	Yield; management practices on 17 farms	Metered irrigation on 13 neighbouring farms as benchmark	Gross margins and grade prices from four packhouses

Each approach filled the same gaps: crop and age maps, yield for tree crops, what is applied, and what the product earns.

Sources: Pôle Digital 2026a, 2026b; FAO and EBRD 2025a, 2025b, 2026a.

THEME 1 · AETI AND WATER MANAGEMENT

AETI shows what crops actually consume, and it differs by crop, age and season

Morocco

625 mm

Median seasonal AETI of avocado orchards (range 300–900 mm), Sep 2024–Aug 2025. It includes 386 mm of rainfall.

Jordan

AETI ≈ ETc

Citrus consumption stays close to estimated crop need and is stable across seasons: irrigation is broadly adequate at satellite scale.

Tunisia

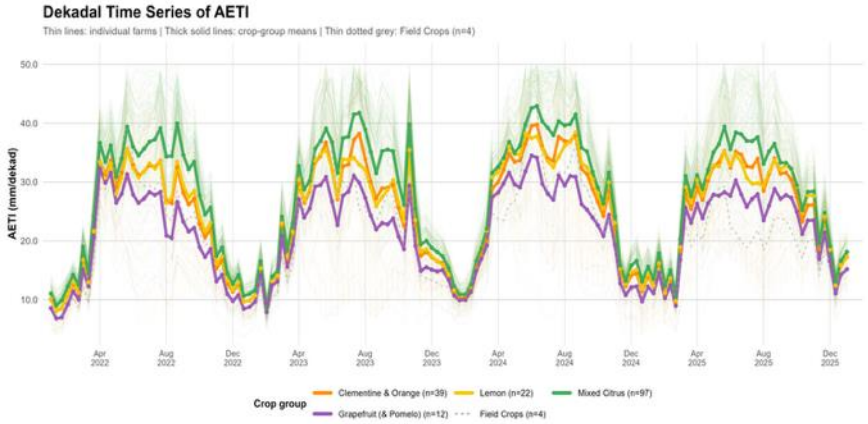
417 vs 379 mm

Cereals used more water in the dry year (2022/23) than in the wet year (2023/24); irrigation peaked in April and May.

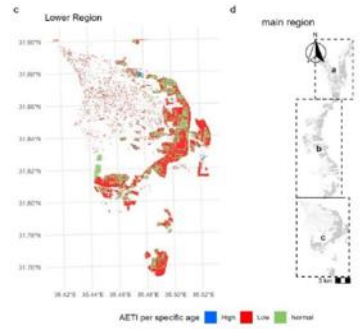
Palestine

±100 mm

Within a tree-age class, 15% of date-palm land used about 103 mm more and 15% about 102 mm less than the normal range.



Jordan: AETI per 10 days by citrus group, 2022–2025



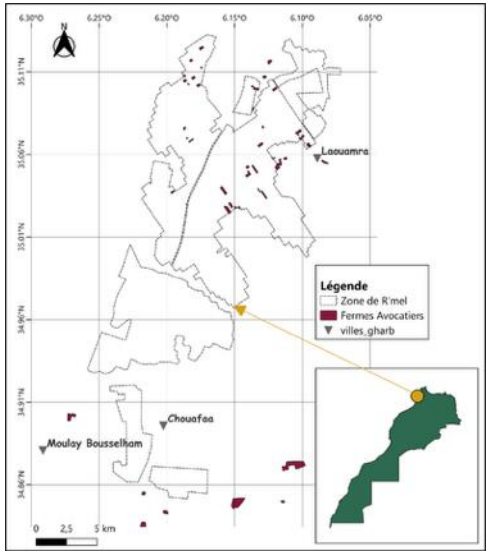
Palestine: orchards with high (blue), normal (green) or low (red) AETI against the norm for their age class

Sources: Pôle Digital 2026a; FAO and EBRD 2025a, 2025b, 2026a.

THEME 1 · AETI AND WATER MANAGEMENT

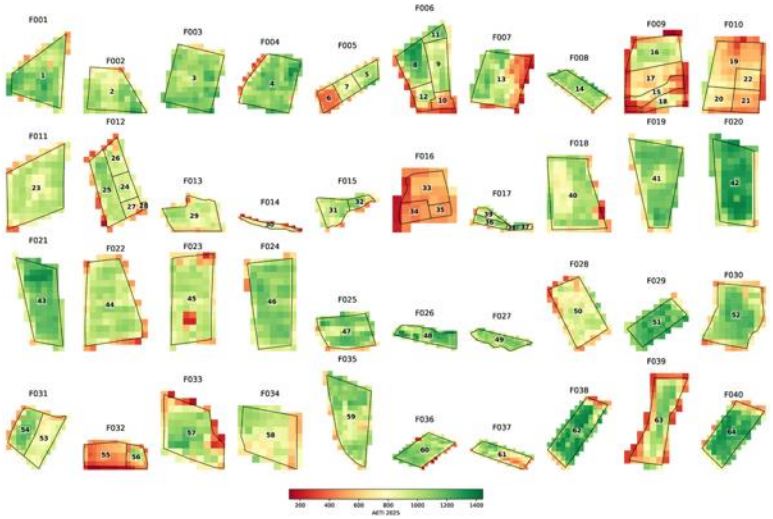
What the satellites see: farm-scale maps of water use and yield in each case

Morocco



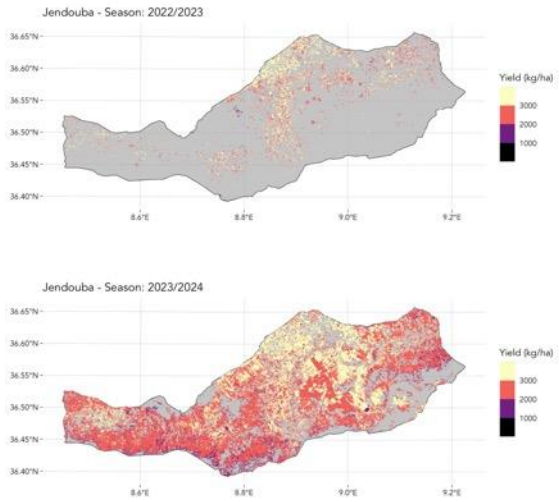
Study area: the 62 avocado farms in R'mel

Jordan



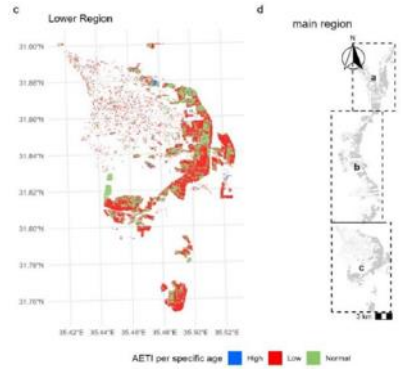
Seasonal AETI by citrus plot, farm by farm (mm)

Tunisia



Cereal yield (kg/ha): dry year 2022/23 (6,878 ha mapped) and wet year 2023/24 (58,064 ha mapped)

Palestine



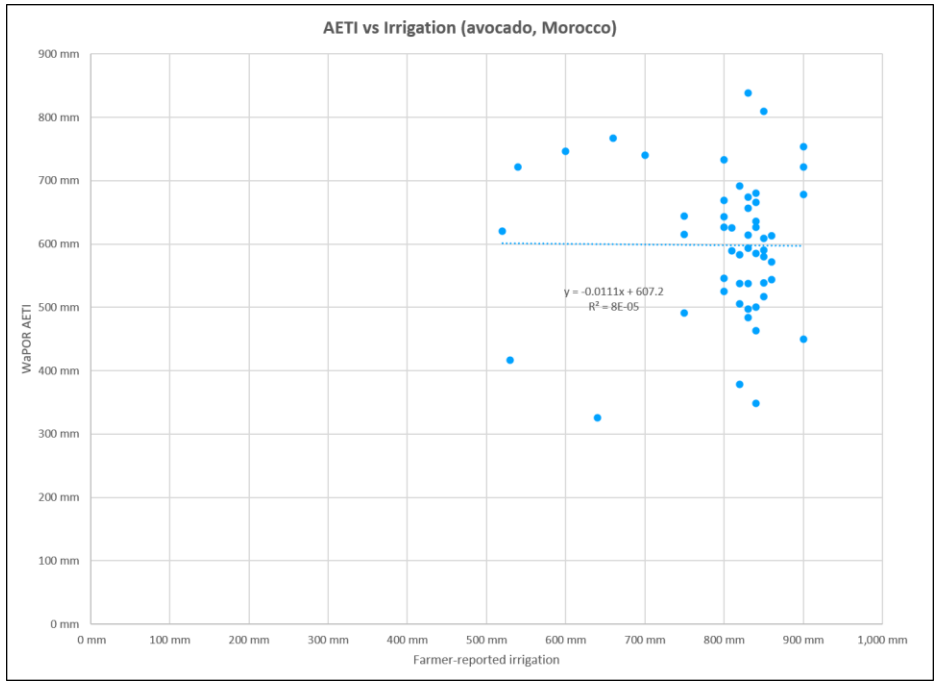
Date-palm orchards against the AETI norm for their age class

Sources: Pôle Digital 2026a; FAO and EBRD 2025a, 2025b, 2026a.

THEME 1 · AETI AND WATER MANAGEMENT

Reported irrigation and satellite AETI show variation – WaPOR fills a gap

Morocco, avocado, farmer-reported



Jordan

No link

No significant correlation between satellite blue ET and reported irrigation in any age group; applied water ranged 14-fold (150–2,171 m³/dunum).

Palestine

Unmetered

Metering is the main data gap: one unmetered farm irrigated almost constantly Nov–Jul; metered neighbouring farms give the benchmark.

Morocco

No link

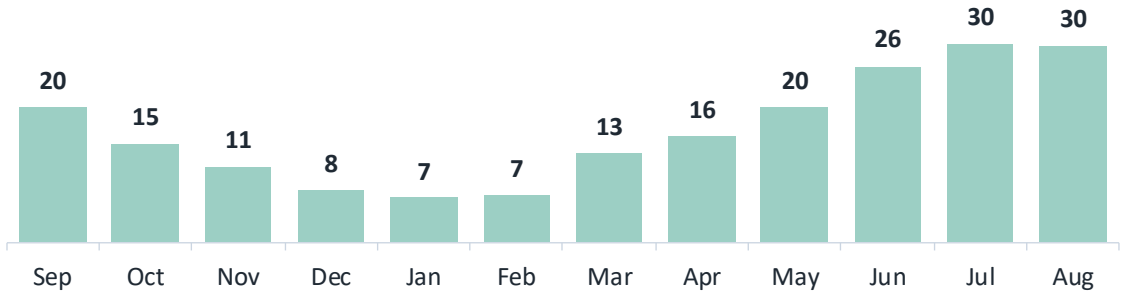
AETI and reported irrigation are unrelated across 56 farms (R^2 = 0.001). Reported volumes are mostly estimated; AETI includes rainfall.

THEME 1 · AETI AND WATER MANAGEMENT

AETI points to when and where to adjust irrigation

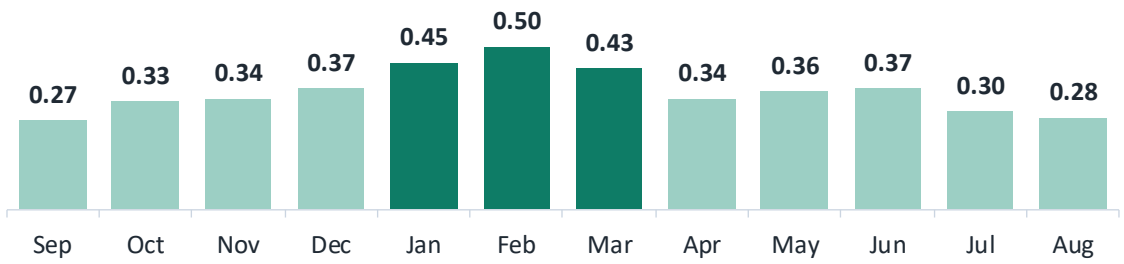
Morocco **Farms irrigate most in July and August**

Mean irrigated days per month, all farms



…but yield is most closely linked to January–March consumption

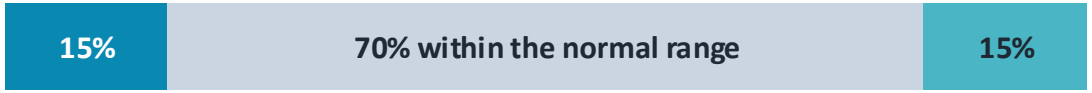
Spearman ρ between monthly AETI and yield, 56 farms



One season (2024/25), not yet confirmed in the field; AETI includes rainfall.

Sources: Pôle Digital 2026a; FAO and EBRD 2025a, 2025b, 2026a.

Palestine **Redistribute, don't restrict**



Over-irrigated: about 103 mm above normal; about 1 million m³ could be saved

Under-irrigated: about 102 mm below normal; about 1 million m³ more needed

Regional total broadly unchanged: reallocate across farms.

- **Palestine, timing:** shift water from winter to June–July. Evaporation from open reservoirs (about 3.6%) exceeds the estimated over-irrigation loss.
- **Jordan:** AETI close to crop need and stable, so gains lie in management, not in more water.
- **Tunisia:** supplementary irrigation secures a crop in dry years; peak demand came in April in the dry year, May in the wet year.

THEME 2 · YIELD AND AGRICULTURAL PRACTICES

Yield, not the volume of water applied, explains most of the difference in productivity

Morocco

71% vs 16.5%

variability of yield vs reported irrigation (coefficient of variation)

Farms reporting similar irrigation volumes obtain very different yields. Mature orchards reach about twice the water productivity of young ones.

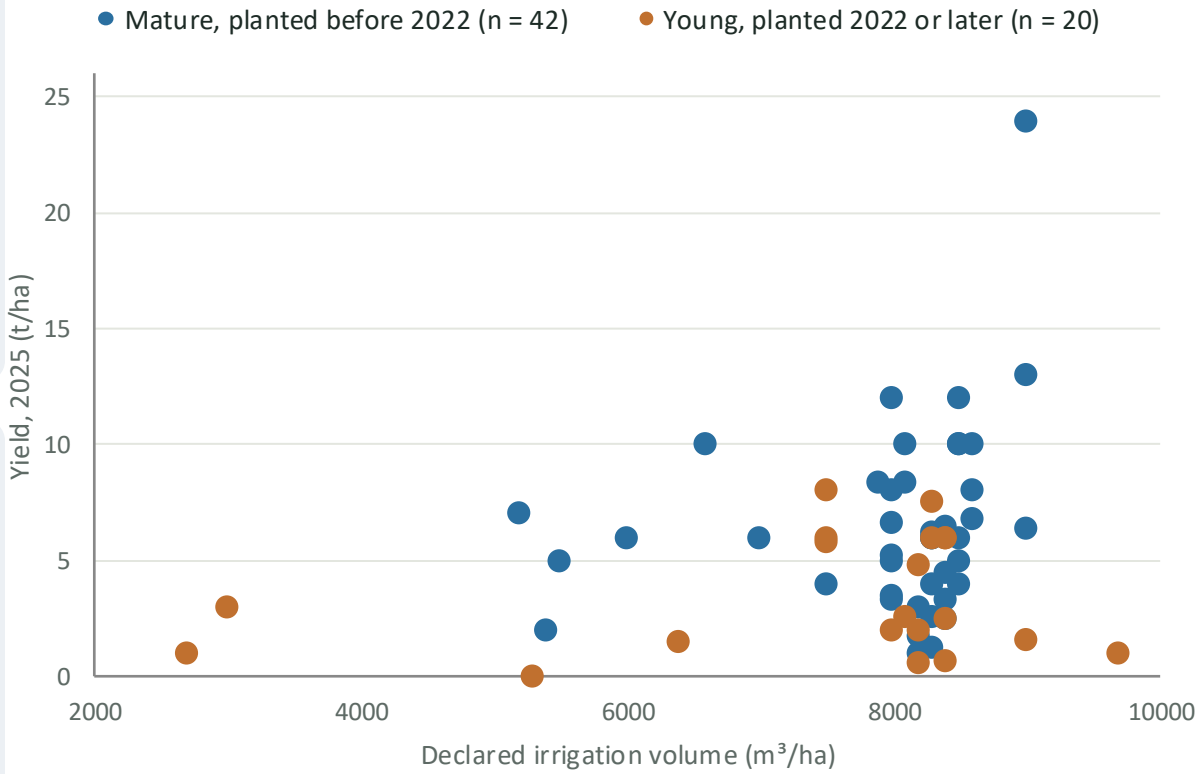
Palestine

18%

of yield variation in mature date palms is explained by AETI

Scheduling, pollination, nutrition and thinning matter more. Yield and water use rise with tree age.

Morocco

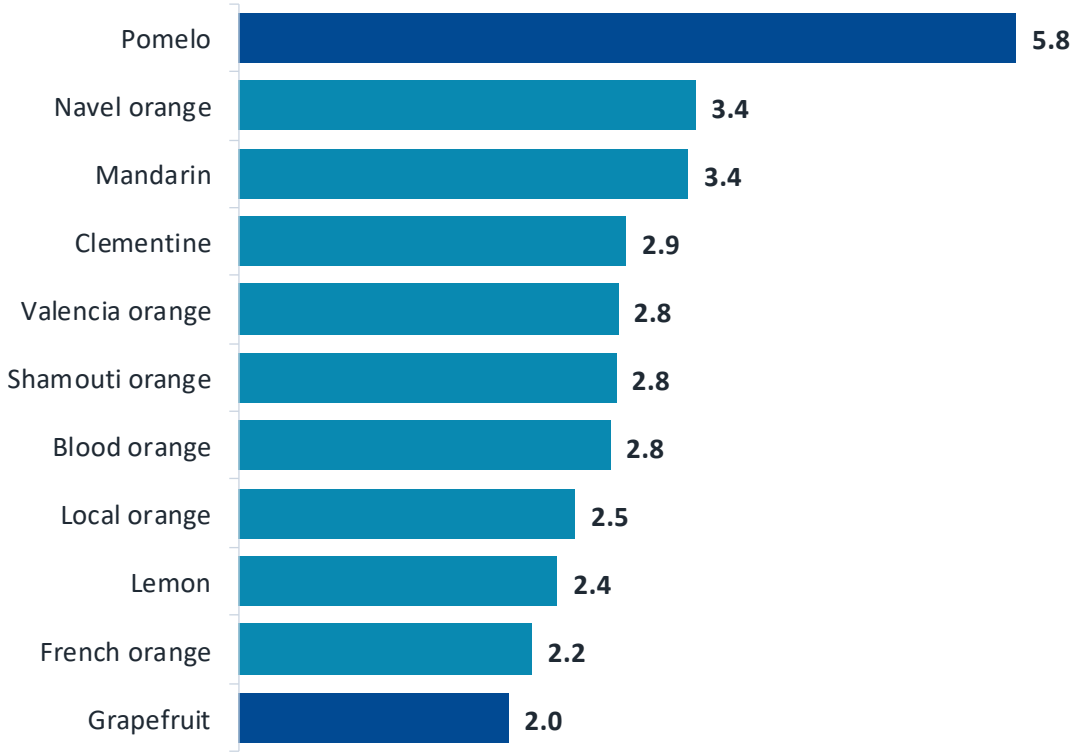


Most farms declare 8,000 to 9,000 m³/ha; on those farms yields range from below 1 to 24 t/ha.

THEME 2 · YIELD AND AGRICULTURAL PRACTICES

Crop choice and orchard age set the baseline, so compare like with like

Jordan citrus: gross-margin water productivity by crop (JD per m³)



Jordan Pomelo earns 2.65 times the gross-margin water productivity of French orange. Grapefruit has high physical productivity (8.3 kg/m³) but the lowest margin per m³ because of its price.

Jordan Technical efficiency rises with orchard age: 75.8% young, 79.9% intermediate, 82.7% mature (learning by doing).

Morocco Mature avocado orchards reach about twice the water productivity of young ones (planted 2022 or later): benchmark within age groups.

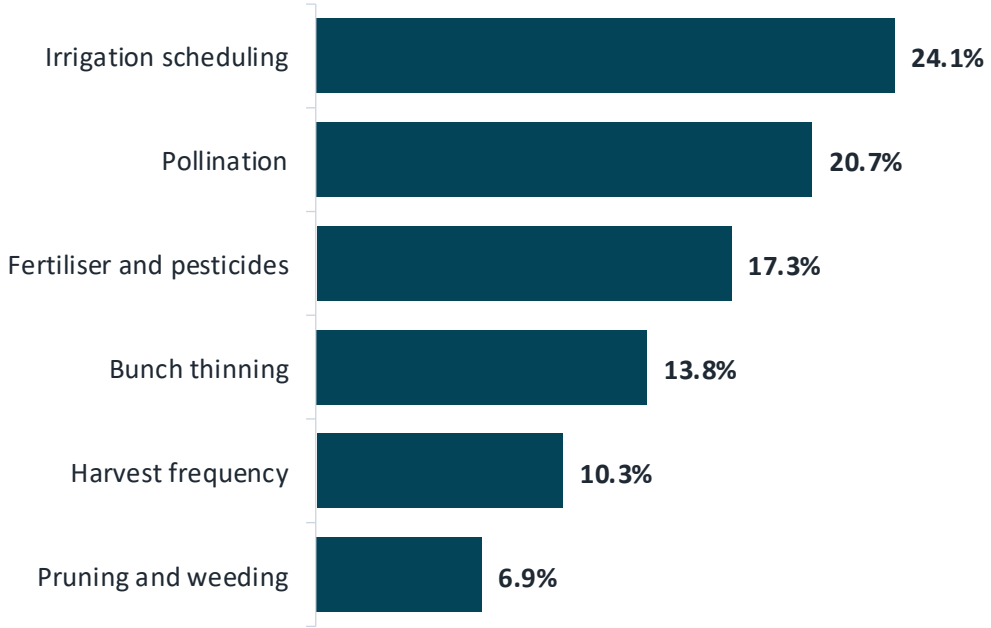
Palestine AETI and yield rise with tree age and water productivity plateaus from about year 16: irrigation advice must be set by age class.

Sources: Pôle Digital 2026a, 2026b; FAO and EBRD 2025a, 2026a.

THEME 2 · YIELD AND AGRICULTURAL PRACTICES

Practices and site conditions explain more than the water source or the irrigation system

Palestine date palm: ranking of management factors (% weight)



Morocco

Mattered: orchard age, wind at flowering (windbreaks), winter cold and summer heat, drainage on heavier soils (reported, not tested).

No clear effect: rootstock, water source, irrigated days; nearly all farms grow Hass under drip.

Jordan

Mattered: tree density (strongest production factor), crop choice and orchard maturity.

No effect: applied water volume (r = 0.01 with technical efficiency).

Tunisia

Mattered: wheat yields trend upward but a technology gap remains; yields swing between dry and wet years.

Not yet surveyed: farm practices.

THEME 3 · WATER PRODUCTIVITY AND ECONOMIC WATER PRODUCTIVITY

A cubic metre of water produces very different amounts, and the water measure matters

Case	Physical water productivity	Water measure used	Spread	What explains it
Morocco avocado	0.87 kg/m³ (median)	WaPOR AETI; on reported irrigation 0.71 kg/m³	Middle half 0.49–1.20	Orchard age: mature about twice young
Jordan citrus	7.4 kg/m³ (mean; median 6.3)	Reported applied water, autumn-season equivalent	1.0–37.4; middle half 4.5–8.9	Crop and management: pomelo 9.0, French orange 6.1
Tunisia cereals	1.6 kg/m³	WaPOR AETI and WaPOR yield	Dry vs wet year only	Rainfall variability (preliminary)
Palestine date palm	1.0 kg/m³ (range 0.5–2.1)	WaPOR AETI with survey yield	0.5–2.1	Tree age: compare within age classes

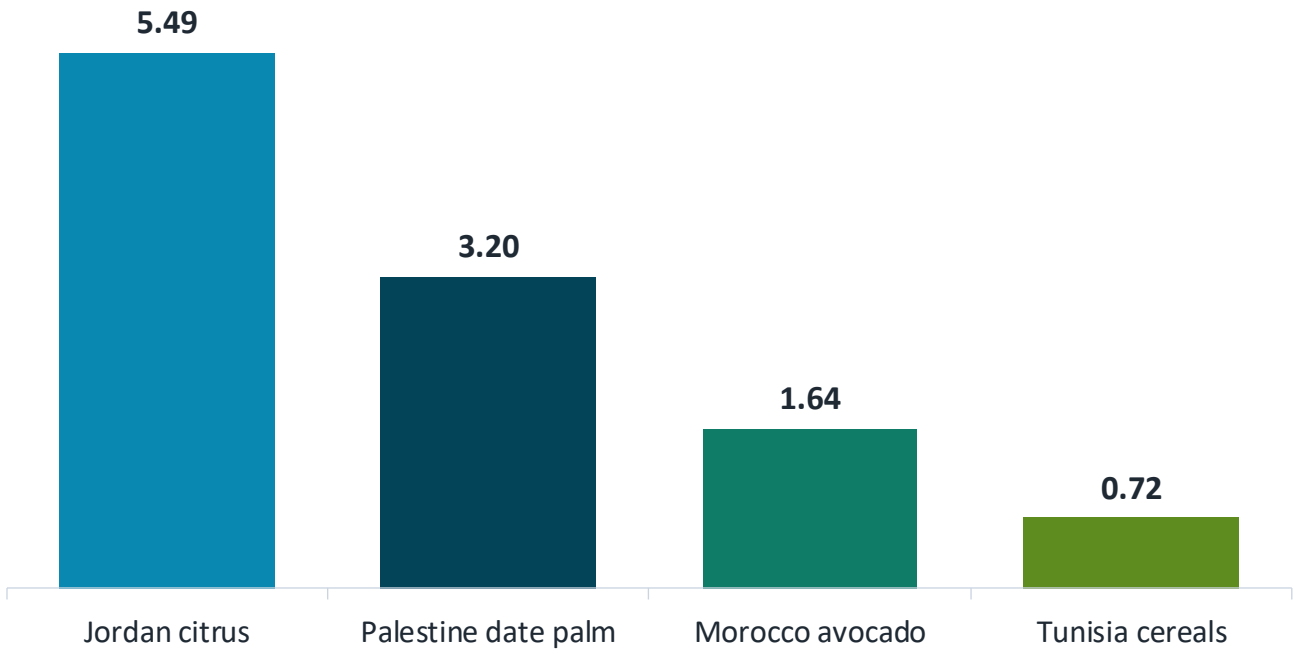
Compare crops with care: kg/m³ depends on the product (fruit, dates, cereals) and on the water measure. The same Moroccan farms give 0.87 or 0.71 kg/m³ depending on whether water is measured by satellite or reported.

Sources: Pôle Digital 2026a; FAO and EBRD 2025a, 2026a, 2026b.

THEME 3 · WATER PRODUCTIVITY AND ECONOMIC WATER PRODUCTIVITY

Water earns far more in high-value orchards- hardly novel but worth mentioning

Gross economic water productivity: revenue per m³ (USD)



Morocco and Jordan: means, per m³ of reported applied water (MAD 0.107 and JD 1.41 per USD). Palestine and Tunisia: as reported in the SWDCC 2026 presentation.

Sources: Pôle Digital 2026b; FAO and EBRD 2026a, 2026b.

≈ 8×

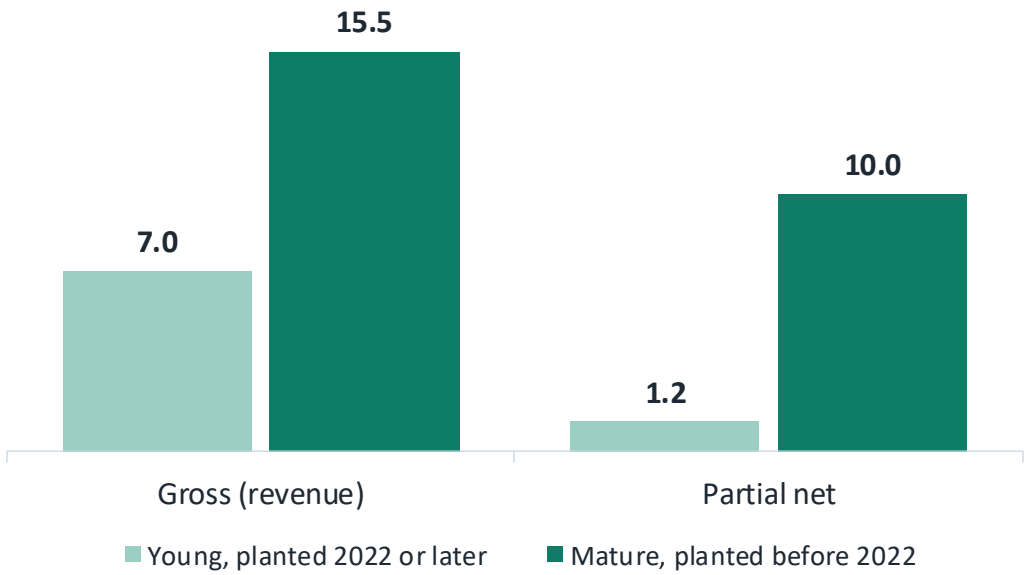
gap in revenue per m³ between citrus in Jordan and cereals in Tunisia

- High-value orchards earn USD 1.6–5.5 of revenue per m³; staple cereals USD 0.7.
- Margins are lower than revenue everywhere, but cost coverage differs between cases (Morocco's net value is partial), so margins are not ranked.
- Cereals still protect production and food security in dry years: value per m³ is not the only criterion.

THEME 3 · WATER PRODUCTIVITY AND ECONOMIC WATER PRODUCTIVITY

Yield, price and quality drive the value of water, not the volume applied

Morocco avocado: median economic water productivity (MAD per m³ of reported irrigation)



Gross: 57 farms; partial net: 38 farms, omitting energy, fertiliser and establishment costs.

Morocco

Value per m³ follows yield and price (ρ = 0.93 and 0.66 with gross value); reported water volume shows none (ρ = −0.08). Yield enters the formula, so a strong link is expected. 87% of farms sell through intermediaries at about MAD 21/kg.

Jordan

Pomelo gross margin is JD 2,636 per dunum against 873 for grapefruit despite its high yield: price decides. More applied water was linked to lower value per m³ ($p < 0.001$).

Palestine

Correcting over- or under-irrigation changes net income by only 0.2–1.6%. Better grading is worth far more: the best grade sells for five to eight times the lowest.

Tunisia

Lowest value per m³ (USD 0.72 revenue, 0.58 margin), and farm revenue swings in dry years.

Sources: Pôle Digital 2026b; FAO and EBRD 2025a, 2025b, 2026a.

LESSONS LEARNT

Lessons learnt (1 of 3): from evidence to investment

1. Physical WP is Production/Yield; EWP is driven by the same two things

2. Farmer-reported water use is almost meaningless, as not measured & not recorded, so: 1) Farm data need meters & records and 2) WaPOR may fill the gap

3. Yield is key and worth checking carefully, matter far more than the price of each pesticide

4. Price comes in third place and deserves more attention - one crop may sell at several prices

5. Quality may or may not matter to the farmer: 1) If government sets the price or wholesales just pay for quantity, quality doesn't benefit the farmer. 2) But if buyers pay for quality, then we need to think how water may affect it

LESSONS LEARNT

Lessons learnt (2 of 3): from evidence to investment

6 Almost no correlation between yield & water, whether farm-reported or from WaPOR

- Measurement errors are part of the story, but probably not the main factor,
- Limited variation in irrigation practice between farms in each survey area,
- Yield depends on many things, yield is just one,
- We found different things in different countries:
  - Tree age for dates in Palestine
  - Tree spacing & variety for citrus on Jordan,
- Many key things are not picked up by quantitative surveys - pruning, thinning, pest control,
- N.B. Agronomy & irrigation are not separate, they are both part of crop production

7 Some indications that when the water was given may affect yield - worth following up

8 Studies identified important issues in each case - the value of WaPOR for strategic diagnosis

LESSONS LEARNT

Lessons learnt (3 of 3): from evidence to investment

9

What would we like to add next time?

- Drill down into farm water use, with water meters & soil moisture meters
- Look beyond the farm gate, at marketing, grading, quality & price
- Bring in local agronomists to answer the key question: "Why did these two groups of fams get such different yields, when they both used the same amount of water?"

10

If farmers don't know how much water they are applying, how can they follow our irrigation recommendations? We need simple, practical tools: "Water now" or "Wait"; "Water more", "Water less" or "Keep doing what you're doing now"

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CAIRO WATER WEEK

Thank you



Thank you

For more information, please get in touch with us:

Food and Agriculture Organization of the United Nations

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